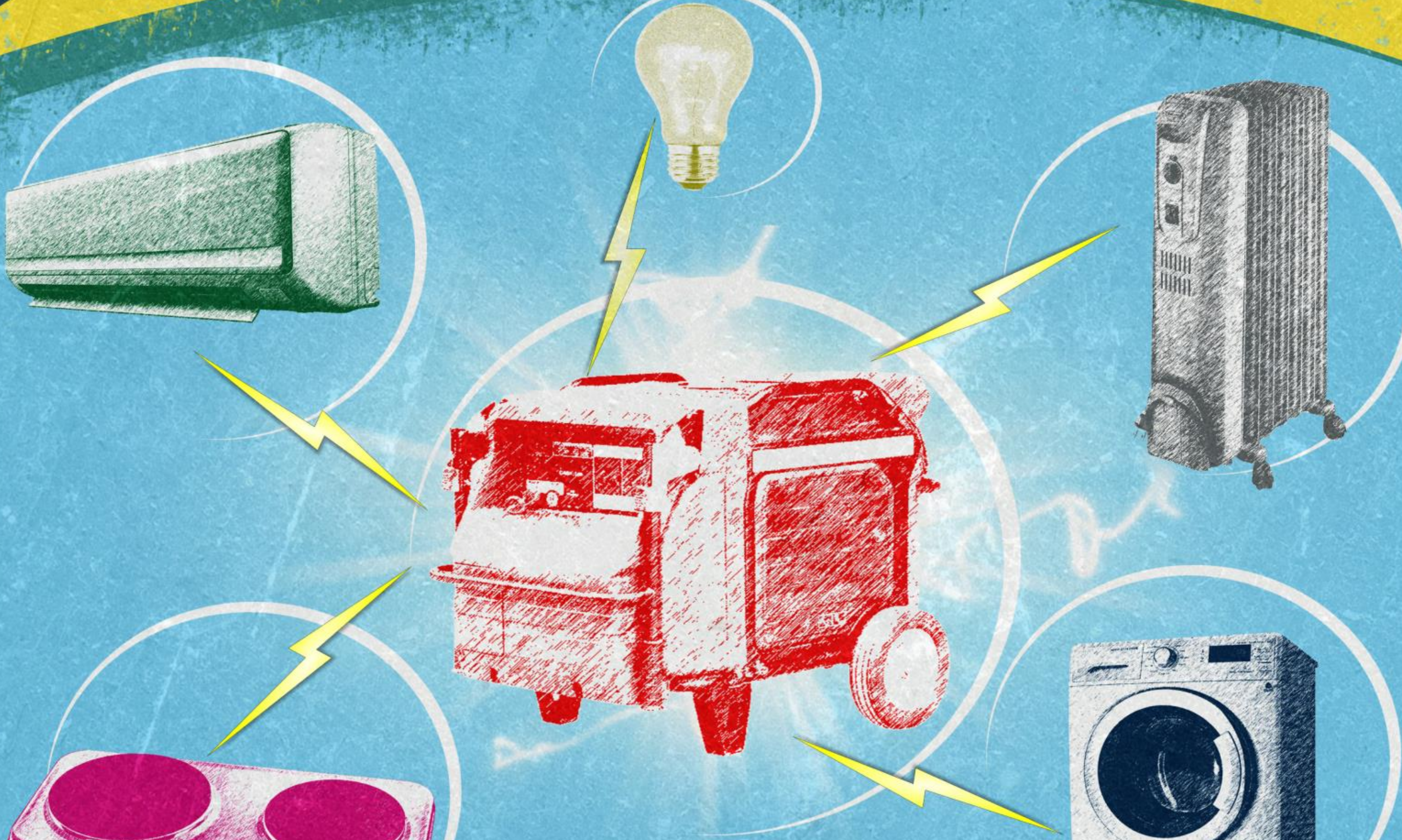
POWER LIBERTY:

THE EMP RESISTANT SURVIVAL GENERATOR



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A Step-By-Step Guide to Building an EMP Resistant Solar Survival Generator

Our modern society is highly dependent on one critical resource... electricity. While electricity isn't normally considered a survival resource, trying to survive without it will make things much harder. Much of what we use on a day-to-day basis requires electricity to operate, so if we lose it, we have to do without those devices.

Granted, our ancestors survived for centuries without the regular use of electricity, so we know it's possible. But there is one huge difference between them and us; they were accustomed to living without electricity. Because of that, they had manual ways of doing much of what we depend on electricity to power.

Unless you have a gas stove, just about everything you do in the kitchen requires electricity to power it. We use electric mixers, blenders, coffee makers, stovetops, ovens, and a host of other appliances. Yet, pretty much all of that was done before electrical power became commonplace. But as electric power became available, the devices our grandparents and great-grandparents used were gradually replaced by electric versions. While those electric versions make things easier to do, they also mean that without electricity, we are stuck.

On a daily basis, the average American family uses electric power to:

- Heat our homes
- Cool our homes
- Wash our clothes
- Heat our water
- Wash our dishes
- Cook our food
- Make our coffee
- Preserve fresh foods
- Light up our lives
- Iron our clothes
- Do our work
- Study our lessons
- Communicate with each other
- Inform us
- And entertain us

That's a lot of stuff that electricity does for us; and I'm not even touching on commercial or industrial uses for electrical power; just what we do in our homes. But what happens when the electric power goes out?

We've all experienced that one time or another; one minute, everything is fine and the next minute the lights go out and everything stops working. When it happens, our lives come to a stop. We have to stop whatever we're doing and figure out where the electricity went. Are we the only ones without power or are the neighbors' houses dark too? How far does it extend? Even more important than that, how long is it going to last?

The truth is, we are poorly equipped to function without electricity. Yet pretty much every disaster brings with it a loss of electrical power. It doesn't even require a disaster for that to happen; all we need is a good wind storm blowing down the lines or an unfortunate squirrel frying itself on the power line transformer. Either way, the lights are out.

But what would we do if the lights went out and didn't come back on? Being without power for a few hours is one thing, but what about days... weeks... months... forever? What would we do then?

While most power outages are cleared up in a matter of hours or at the worst a few days, it's not that unusual for serious snowstorms to cause power outages that can last over a week. Hurricanes are even worse, with people having to do without power for weeks after both Hurricane Katrina and Hurricane Sandy.

Actually, the chance of being caught in a prolonged power outage is increasing. According to studies by the Department of Energy, power outages are on the increase as well as the duration of those power outages. That's largely due to the age of our electrical infrastructure, which is getting worse by the day. Due to a combination of government red tape and insufficient industry funding, the electrical grid isn't being updated quickly enough.

The specific problem is that the electrical infrastructure was built with an expected 50 year lifespan. But much of it is past that point. We have electrical lines that are over 100 years old, which are still in use. Many of our older power plants can't be retired, simply because there is not enough capacity to replace them.

In the latest Infrastructure Report Card by the American Society of Civil Engineers, the energy category, which includes electrical grid received a D+ rating. In reading the write-up, it seems that the reason the rating was so high was that other energy considerations raised up the rating of the grid. Fixing the current problems would cost over one trillion dollars, but that's not the biggest problem. The big problem is that the government won't issue the permits to build new power plants, sub-stations and transmission lines.

With the grid in such bad shape, it's no wonder that people lose power whenever there's a natural disaster. But even that isn't the worst risk we face. The biggie is the risk of enemy attack against the grid. As a cheap mission-kill, attacking the grid would be the easiest way to take the United States down; and it wouldn't be all that hard to do. It could be done by:

- Direct terrorist attack (that's already been tried and tested)
- Cyber-warfare (our grid is under constant cyber probing and attack)
- High-altitude EMP (caused by exploding a nuclear device above our atmosphere, an attack that at least two enemy nations have

the capability to do)

I realize that all sounds rather bleak, but I'm really not trying to be a fear monger. What I'm trying to do is give you a realistic appraisal of the high risk of a serious power outage. With the world situation as it is, chances are that you're going to face some sort of a major power outage sometime in your life, perhaps more than one. You and I might even be faced with a total loss of the grid, especially if one of our country's enemies takes it out with an EMP attack.

Fitting this into Your Survival Plans

Okay, so if we figure that it's a given that we are going to experience a prolonged power outage at some time in our lives, it only makes sense that we figure out how to deal with it. That basically means one of two options; figuring out how to do everything without electrical power and then buying the equipment to do so or figuring out how to generate our own electrical power.

The truth is, we'll probably all end up doing something in-between those two possibilities. Generating all your own electrical power is a major undertaking. On the other hand, trying to do everything without electrical power means having to leave some important things out of your life. So, you'll need to generate enough electrical power for the absolute necessities, while finding other ways to take care of things, so that you don't need to generate as much electrical power.

For most of us, we're going to be doing this in our home. Unless you have a cabin or bunker hiding in the woods somewhere, you're better off trying to bug in, than you would be to bug out. Bugging out and living in the wild is extremely difficult, and your chances of survival are minimal. By bugging in, you ensure that you have shelter, as well as everything you own, to help you survive.

While most of us don't have all that much survival equipment, we do have a lot of things in our homes, which can be adapted for use in a survival situation. So, bugging in increases your chances of survival over bugging out. That is, unless you really do have that cabin hiding in the woods. In that case, what we're going to talk about here can be done for the cabin, rather than limiting your thinking to doing it for your home. In either case, we're going to make it portable anyway, so you can take it with you.

Generating enough electrical power to take care of all your home's needs is expensive. But there's no reason why you can't create a system that will allow you to generate enough power to use some electrical devices. Which devices you use depends on you. I would prioritize, based on your most critical needs. What are those?

- Medical devices that family members need
- Charging cell phones
- A radio to receive the news
- Recharging power tools
- Some small kitchen appliances (used sparingly)
- Recharging batteries for LED flashlights
- Limited lighting (LED only)
- Well pump (assuming you have a well)

The basic problem is this; generating electricity in any quantity is expensive. That's why I've created such a limited list. Unless you have $30,000 or more that you can spend on alternate energy, you won't be able to power your home. I looked into a complete alternate power system for my home, and the total cost to produce my average power consumption was going to be $59,000. That's when I decided to build my own survival generator.

So, that means that there are a number of things that you will need to find alternative means of doing, without electrical power. Fortunately, there are answers for all of these. Some will require that you buy something that you don't have now and others will require that you learn new ways of doing things; but in all ways, you'll be able to keep your home going.

- Heating - Fireplaces and wood-burning stoves are the best. Firewood is a renewable resource that you can harvest yourself, making it very practical for a survival situation.
- Lighting - You can use candles and oil burning lamps. If you have a fireplace, it will provide some light too. Alter your schedule to use all the daylight you can.
- Refrigeration - This one is tricky. The best is to have a root cellar. If you can't do that, then some sort of evaporative cooling is good. Refrigerators use a lot of power, but a small one could be run off the generator.
- Cooling - Air conditioning is going to be out, as it uses a lot of electricity. You're going to be limited to evaporative cooling, shade and a nice cool breeze.
- Cooking - Cook in the fireplace, over the wood-burning stove, on

the barbecue grille, over a fire pit, on a camp stove or with solar power. There are lots of options.

- Food preparation - There are hand-powered mechanical versions for most of the small appliances we have in our kitchens today. The one thing you may want to do electrically is grinding grain for baking.
- Ironing clothes - You may just have to go without ironing them, although a hot saucepan or frying pan works pretty well as an iron.
- Heating water - Over a fire, just like cooking.
- Washing clothes - You'll have to do that by hand.

With these other methods replacing your normal use of electrical power, the actual amount of electricity you need will be greatly diminished. That brings it down to the realm of what you can manage as a do-it-yourself project. As I'm going to show you, you can build your own power generator fairly easily, if you have typical skills for building things.

The most critical skill for this project is the ability to solder electronics. If you don't know how to do this, don't worry, I'll show you. But you'll want to practice plenty, before actually working on your generator.

Possible Sources of Electrical Power

Okay, so let's start talking about the nitty-gritty. How are you going to produce electrical power? There are actually several methods available, although they are not all practical in all situations. In fact, there's really only one that is practical in pretty much all situations. That's the one we are going to use. Our choices are:

- Gasoline generator - A generator burns gas to produce electricity. While those that burn automotive gasoline are the most common, they also come for burning diesel, propane and natural gas. The problem here is that you need a constant supply of gas. That's almost impossible to get in a crisis situation and extremely expensive at any time.
- Water power - If you happen to live by a river, you could build yourself a water wheel. Geared up to a higher speed, it would be enough to produce electricity. That would provide free power, once the wheel was built. But few of us actually have a situation which allows for that.
- Wind power - Wind is an excellent source of power and in fact is becoming more and more common for commercial electric power generation. Unfortunately, those massive wind turbines are beyond our capability. While we could build a small one, they don't work in all places. You basically need a constant 10 mile per hour wind to produce electricity.
- Solar power - Solar has become the most popular means of generating your own electricity. That's basically because solar is consistent, works just about anywhere and is fairly simple. We're going to use solar power for those very reasons.

So, you and I are going on an adventure together, one of building our own solar powered generator. This may seem like something that is beyond you, but I guarantee you, it's not all that hard to do. Actually, it's more tedious than it is hard.

Let's Talk Electronics

Before we get into starting to build the generator, it would help if we had an understanding of some basic electronic principles. That way, we'll understand what we're doing and why we're doing it. It will also help if you have to do something else, such as modifying your system in the future. [1]

Pretty much all home appliances, light bulbs and anything that plugs into a wall outlet are designed to run off of 120 volts of alternating current (AC). Most handheld electronics today are designed to run off of 5 volts of direct current (DC). Those that are can easily be identified, because they will charge off of a USB port on a computer or use a USB wall charger.

Okay, so what do those terms mean? To start with, we can think of current like the current of a stream. In the case of a stream, we have water flowing downhill. In the case of electricity, we have electrons flowing down a wire. Downstream generally means going from the negative pole on a battery through the wire or device and back to the positive pole.

But what are these electrons? If we go back to high-school chemistry, we find that atoms are made of three basic components; protons, neutrons and electrons. The protons and neutrons form the nucleus

[1] I'm going to try to simplify this a bit, so if you're an electronics guru, you might find yourself offended by my explanation. If so, please keep in mind that I'm an electrical engineer, so I know how I'm butchering the technical definitions. I'm trying to make it quick and easy for people to understand, especially understanding the relationship between the various terms.

and the electrons fly around the nucleus in orbits. Those are the same electrons we're talking about in electronics. The only difference is that when electricity is flowing, giving us "current," those electrons go from atom to atom along the wire.

I mentioned two different types of current back there, alternating current and direct current. Direct current means that all the electrons are flowing the same way down the wire. It's what I was talking about when I said that they went from the negative pole of a battery, through the wire or device and ended up at the positive pole of the same battery. Alternating current means that the electrons move back and forth, alternating their direction. Here in the United States, they change directions 120 times per minute, or 60 cycles (a cycle is defined as there and back, or more correctly from zero volts, to plus 120 volts, to minus 120 volts and back to zero volts).

Since electricity is the movement of the electrons, it is possible for devices to be designed for use with direct current or alternating current. But most devices will only work with one or the other. Incandescent light bulbs are one of the few exceptions to this rule.

I also mentioned the term "volts" back there. Specifically, I said that most home electronics use 120 volts and most handheld electronics use 5 volts. Technically, this term refers to the electricity's "potential." But that doesn't help us much. It's easier to think of it as how strong the electricity is. The right strength has to be used with a device; if it is too weak, it won't make the device work and if it's too strong, it will break the device.

Think of it this way; if you have a robot that is supposed to pick up eggs and place them in cartons, the robot had better be adjusted extremely well. That can be hard, as eggs vary in size. So, the robot would have to sense how much pressure it was putting on the eggs, or how strong it was clamping. Too much and it would break the eggs, too little and it can't move them.

So voltage can't be too strong or too weak. It has to be just about right. There is an exception to this, but we'll talk about that later.

Finally, there's one other term that I need to explain; that's the one used to measure how much current we have. We'll call this one power. For our purposes, it can be measured in one of two different ways, as watts or as amps.

The easiest way to understand this is with a garden hose. The size of the hose is the size of the wire. How fast the water comes through the hose is determined by the volts, but how much water comes through is determined by the watts or amps. While there is technically a difference between the two, for our purposes, they both refer to how much water is coming through. But we must remember that as that water comes through the hose, it gets consumed.

The owner's manuals will tell us how much power some devices consume, measured in watts. Others will tell us how much power some devices need, measured in amps. It can get confusing. But fortunately, converting from one to the other is actually quite easy.

- To convert watts to amps, divide the watts by the voltage. W ÷ V = A

- To convert amps to watts, multiply the amps by the voltage. A x V = W

Bookmark those two equations, because you are bound to need them sometime, as you work with your power generator.

More on Household Electronics

I mentioned that household electronics are designed for 120 volts AC. That's true, but there is a caveat. The device connects to 120 volts AC, because that's what the electrical grid is providing to your home. However, some devices use much less voltage than that.

Basically, if the device you're connecting to the wall outlet has a motor as its main component, then it probably runs off of 120 volts AC. This includes all of your kitchen appliances, your refrigerator, the washing machine (not the dryer, it runs off of 240 volts AC) and the vacuum cleaner. Home incandescent, fluorescent and the new CFL light bulbs also run off of 120 volts AC; although there are also light bulbs that run off of other voltages as well.

However, anything that can also run off of batteries or that has a cord with a transformer box at the end is running off of less voltage. Most of your home electronics, such as entertainment equipment, cell phones and laptop computers fall into this category. In the case of these devices, the power adapter is there to convert the 120 volt AC power your wall outlet provides into some other voltage, which is probably also direct current. You can tell what voltage they use by looking at the tiny writing on the power adapter.

Many of these devices can also be powered off a cigarette lighter adapter. The advantage of that is that when you convert from 120 volts AC to 12 volts DC or to 5 volts DC, there is a certain amount of power that is lost. This lost power converts to heat and is never seen again. But if you power these devices off of 12 volts DC, you'll actually get more bang for your buck. We'll just have to make sure that our power generator will give us 12 volts DC (it will).

Then there is a third category of electronics in your home, those that aren't battery powered, but connect to your home's power instead. Your television, desktop computer and home stereo all fall into this third category. These devices don't have a separate power supply to connect them to the wall, they have a power supply inside of them. A desktop computer, for example, has an internal power supply, which converts the 120 volt AC power in your home into 5 volt and 12 volt DC power.

It is also possible to get into the power supplies of many of these devices and modify them so that they can be connected to a 12 volt DC or 5 volt DC power supply, such as we will have available from the power generator. Unfortunately, that requires quite a bit of knowledge about electronics, as well as the schematic diagrams for the particular device. We're not going to get into that; I merely mention this in case you have an electronics guru in your survival team.

Solar Panels and Electricity

Since we're building a solar power generator, we need to talk about solar panels and the electronics associated with them. There's a bit more here than just connecting a couple of wires together.

Solar panels are made of a series of solar cells, connected together. The good news is that by building them yourself, you can save about half the cost of buying them. I don't know about you, but I'm always looking for an opportunity to save a buck; this helps.

Solar cells come in different sizes ranging from about one inch square up to six inches square. All of them put out the same amount of voltage, but they vary in the amount of wattage they provide. Solar cells, from the smallest to the largest, all put out 0.5 volts DC. The six inch square ones put out 4 watts and the 3 x 6 inch ones put out 1.6 watts.

That's not enough power to do much with, so it's normal to connect a bunch of solar cells together, making panels out of them. The way we connect these together is extremely important, so that we get the output we want.

Let me jump ahead here a moment and say that we're going to use 12 volt batteries to store the power produced by our solar generator. I'll explain later why we're doing that, but I need to mention it here, because we need our solar generator to put out enough power to charge that 12 volt battery. That means we need more than 12 volts out of our 0.5 volt solar cells; quite a bit more.

Here's how we do that; we connect solar cells together.

Solar cells and batteries work much alike. When you connect batteries together, end to end, such as in a flashlight, it's called connecting them "in series." To be in series, the negative end on one battery has to be connected to the positive end on the other. In the diagram, you'll see two batteries inside a flashlight. The positive end of the top battery (the gold end) is connected to the negative end of the other battery (the black end). This makes the two in series.

When batteries or solar cells are connected in series, the voltage is added. So, in the example of our flashlight, the two 1.5 volt D-cell batteries are providing a total of 3.0 volts of power to the flashlight. If we had a three battery flashlight (3 cell) it would be providing 4.5 volts of electrical power.

To get 12 volts of power out of our 0.5 volt solar cells, we need to connect 24 of them together in series (0.5 x 24 = 12). But in reality, we're going to want to get about 18 volts out of our solar cells, so we need to connect 36 of them together in series (36 x .05 = 18).

There's a second way that batteries and solar cells can be connected together; that's called "in parallel." To be in parallel, the positive ends of all the batteries or solar cells have to be connected together and the negative ends have to be connected together. When this happens, the voltage of the batteries or solar cells isn't added, it remains the same.

But something does change; the power output. So, if we had two 3 x 6 solar cells, which each put out 0.5 volts at 1.6 watts, and we connected them together in parallel, they would put out 0.5 volts at 3.2 watts. Actually, what we do is to connect strings of 36 solar cells together in parallel. That way, we have 18 volts at 3.2 watts for two strings; 18 volts at 4.8 watts for three strings and 18 volts at 6.4 watts for four strings.

Building the Solar Panels

Okay, now that we have a bit of understanding about the electronics of what we're trying to do, let's get to the actual building. To start with, we're going to need some solar panels, as those are what are going to create the electrical power for us. You can actually use as many panels as you want and can afford, but for the sake of these instructions, we're just going to have one in our system.

As I mentioned before, a solar panel is made up of solar cells; specifically 36 solar cells. While commercial panels may have more than 36 cells, for our purposes 36 is enough. This number also works out well if you buy pre-made solar panel frames, as they are usually designed to hold 36 cells.

Solar cells either come tabbed or untabbed. This refers to whether or not the cells already have tabbing wire soldered to them. Tabbed cells are a bit more expensive, but they will save you a fair amount of rather tedious work. I'm going to use untabbed cells, which are both cheaper and usually easier to find.

There are a number of places you can buy solar cells, but the easiest is to take a look around eBay. Typically, they'll be packaged with a few extra cells, so you'll get a package of 38 or 40 cells. The package should also contain tabbing wire, bus wire and a solder flux pen. Buying enough solar cells for several panels at a time is more cost effective, giving you a lower price per cell. These cells can be bought as:

- Whole, unbroken cells - Perfect cells that have no chips or cracks in them. As such, they provide the maximum possible power output for that cell size. However, they cost the most.

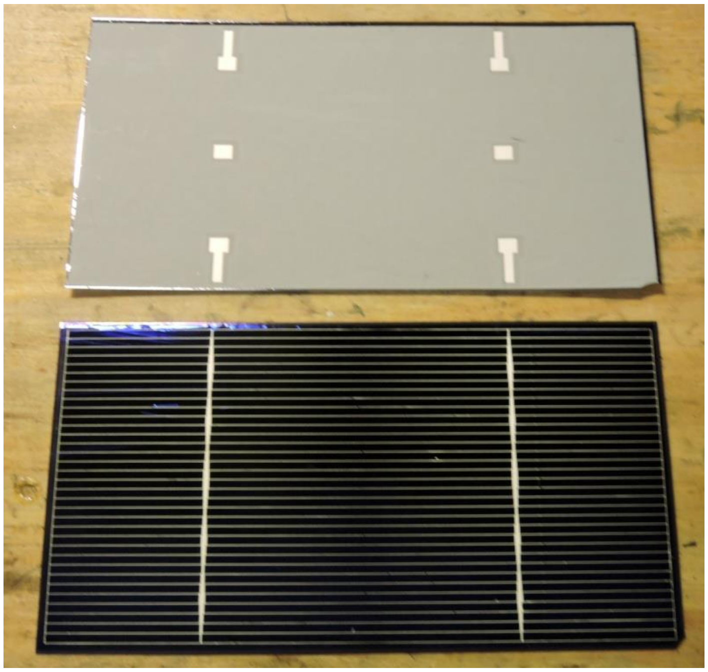
- Chipped cells - Cells will have some chipped corners and small cracks. The chips will be small enough that the amount of power loss will be negligible. They are considerably cheaper than unbroken cells. This is what I use.
- Broken cells - Cells that are broken or cracked. There will be a number of cells in the package that are incomplete, perhaps only 2/3 the original size. While the cheapest option, you will receive less power output in watts from these cells.

It's appropriate to note here that solar cells are extremely fragile. They are made of paper thin glass, which makes it extremely easy to break them. Extreme care must be taken in all phases of handling to prevent breaking the cells.

If you have a cell that is cracked, but not broken, you can tape it on the back (grey) side to hold it together for handling. The tape must not cover up the solder pads, as you will need those. It's also not a good idea to have tape in the middle of the cell, as that's where you will be attaching it to the panel backing board.

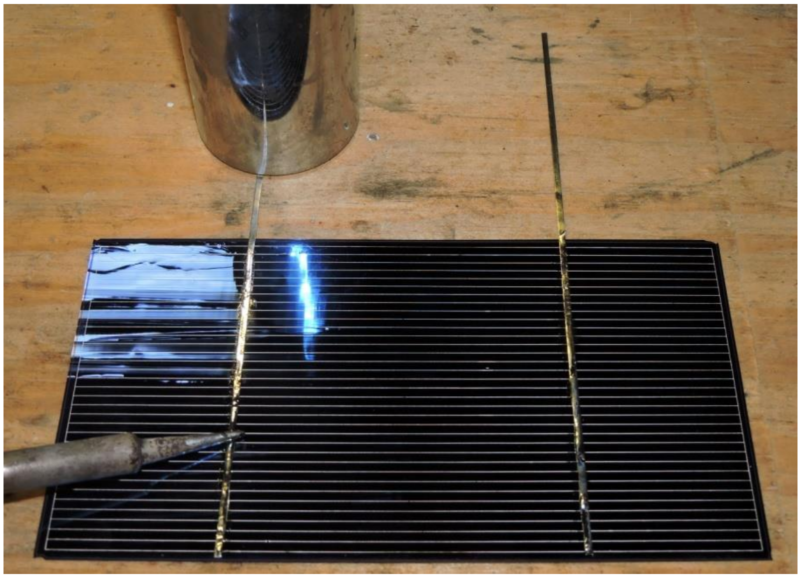
Tabbing the Cells

Like a battery, a solar cell has a positive side and a negative side, as shown in the picture below. The face side, which is blue, is the negative side. The silver lines on this side are the wires to carry the gathered current to the solder pads. The solder pads are the two white lines. On the back or grey side, you see six white pads, these are the solder pads for the positive side of the solar cell.



To start, tabbing wire needs to be attached to the negative side of the solar cell. Tabbing wire is a 2mm wide, flat, uninsulated wire. It is silver colored when you buy it, because it is already coated in solder, in a process called "tinning."

Tabbing wire will come either on a small spool or wrapped around a piece of cardboard. Either way, it needs to be cut to length, twice the width of the solar cell. Since I'm using 3"x 6" solar cells here, that means the tabbing wire would need to be cut to pieces six inches long. You'll need two pieces of tabbing wire for every solar cell you have.



Before soldering the tabbing wire onto the cell, take the flux pen and put a line of flux down both of the solder pads. To get the flux flowing in the pen, you'll need to push down on it on some hard surface. Don't try pushing on it on a solar cell, or it will break the cell.

Since the tabbing wire is already tinned, it is possible to solder the wire directly to the pad on the cell. However, I've found that when I try that, the wire doesn't always stick well. So what I do is to put some solder on the soldering iron tip and run it down the pad, tinning the pad. You don't need a lot, just enough to be like you are painting the pad with solder.

Lay the tabbing wires on the solar cell, so that it overlays the soldering pads, as shown in the photo above. The silver thing in the background is a large socket I use to hold the wire in place. I hold the other end with a soldering tool, kind of like a pick. You can't see it, because that hand is holding the camera.

The soldering iron is then run over the tabbing wire slowly, from one end to the other, melting the solder on the tabbing wire and solder pad together. You can gauge the speed of your movement by looking at the solder, when it is melted, it will look shiny, like it is wet. As it cools, it dulls. So, move the soldering iron at the speed that it can melt the solder.

You'll need a fairly good soldering iron. A 30 watt one should do. I use a temperature control iron, setting it at 700°F. Any hotter may damage the solar cell. Cooler might not solder. Don't use a soldering gun, as it is too clunky and hard to control. Neither should you use a soldering torch.

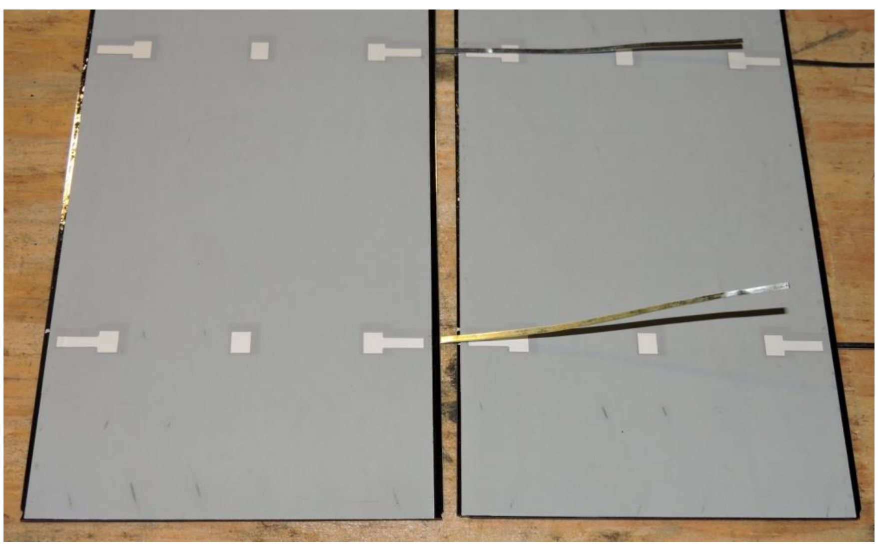
Repeat this process for all the cells you have, setting them aside in a safe place as you finish them. They can be stacked without risk of breaking.

Making Strings of Cells

The next step is to solder the solar cells together, in series, to make strings. We ultimately want a string that's 36 cells long, but we don't want to make that all in one piece. A string that long, made of 3"x 6" cells, would be over nine feet long. Unless you have some really big pieces of glass lying around, that's not going to work. So, instead we make 4 strings of 9 cells (4 x 9 = 36) or 6 strings of 6 cells (6 x 6 = 36). I'm going to use 4 strings of 9 cells, as that works out to be closer to being a square solar panel.

To string them together, we need to lay the solar cells on their face, with the positive side (grey side) of the cell up. Push the cells as close together as you can, while still leaving enough room for the tabbing wire to come up between cells. A gap of 1/16" to 1/8" is fairly typical. The tabbing wires, which are already soldered to the negative side of the cell, will be soldered to the positive side of the next cell in the string, as shown in the photo below.

Before soldering, you'll need to use the flux pen to put flux onto the solder pads on the back of the cells. You may also want to tin the pads (I do) with solder to ensure good adhesion. While these in the picture have six pads per cell, some solar cells will have more or less. In any case, they should align properly with the tabbing wires from the negative side of the adjacent solar cell.



I'd also recommend using a straight edge, attached to your workbench top, so that you can make sure that you are aligning the cells in a straight string. If they are not straight, you may have trouble when you try and fit the strings together to make a solar panel out of them.

The last cell on one end will have tabbing wires, with no cell to attach them to. That's okay; you'll be attaching them to something later. Just leave them hanging off the string and don't worry about it. You'll also have a cell at the other end, with no tabbing wires from an adjacent cell to attach to the positive side. Instead, solder two pieces of tabbing wire to this cell, as if they were coming from another cell. Those will be attached much like the extras at the other end.

Putting the Strings Together

Since we have four strings of nine cells, we need to put them together to form one string of 36 cells. But in order to make the string usable, we're going to double it back on itself, so that the overall shape of the solar panel ends up being a nearly square rectangle.

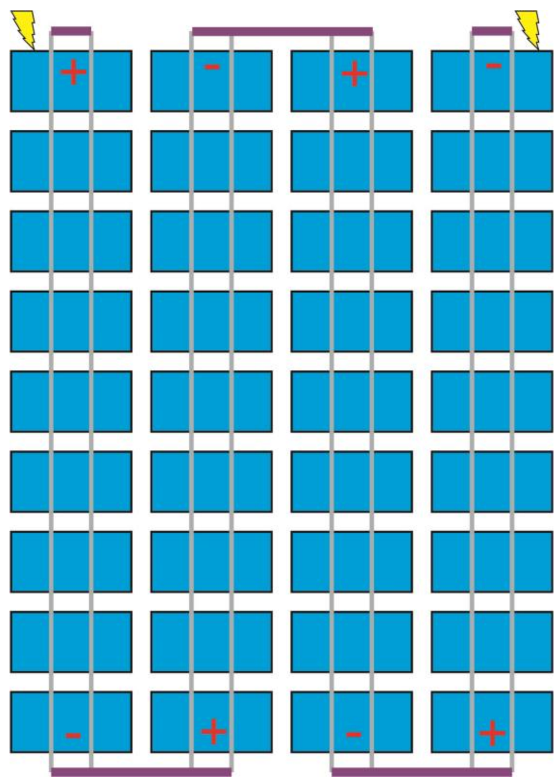
It is necessary to mount the solar cells to a backing board, before connecting them together. Otherwise, it will be impossible to move the cells, without breaking them. While just about any material can be used for the backing board, plywood is best; preferably a plywood with smooth surfaces on both sides, such as a cabinet grade plywood.

Cut the plywood panel to fit the overall size of the solar panel you are building. That has to be a minimum of 26.5" x 32" for 3"x 6" cells. This size will give 1/8" of space between each cell and a 1/2" border all around. The border is necessary so that the frame doesn't overlap any part of any of the cells. A 3/4" border is better, as it will help ensure that the shadow of the frame doesn't overlap any part of any cell.

If you are using commercially manufactured frames, you'll need to cut the wood to fit those frames. But if you are making your own frames (we'll talk about that in a bit), you need to determine the size of your frames and cut the plywood backing board to fit. In all cases, the plywood backing board and the glass for the panel must be the same size.

Backing boards should have all edges sealed with acrylic-latex caulking to prevent water seeping in. the edges are the most vulnerable part of the plywood, so this extra precaution helps to preserve your solar panels, ensuring a long life. Paint both sides with a heavy coat of latex-based paint , to waterproof it.

Draw a grid on one side of the backing board, so that you will know where the center of each solar cell is. The diagram to the right shows the layout of the cells in your panel. This is for 3"x 6" cells. The drawing is not fully to scale. Assume 1/8" of space between each cell. Please note that the strings change direction, with the negative end of the string next to the positive end of the adjacent strings. This is critical! If you don't get this right, you're going to have a very hard time connecting the strings together.



The easiest way to attach the individual solar cells or strings of solar cells to the backing board is with silicone caulking. With the grid drawn, put a dollop of silicone caulking, about the size of a dime, at the center of each cell in a nine cell string.

Holding a string of cells by the tabbing wires at the ends, suspend it over the silicone, being careful to make sure you have the alignment correct. When you are sure, gently lower it to make contact with the silicone. Gently press down on the center of each cell, squishing the silicone beneath.

Please note: It is not necessary for the solar cells to be in contact with the backing board. Allow them to "float" in the air, about 1/16" above the board. As long as the cells are level with the board, they will stay that way, when the silicone dries.

Repeat this procedure for the other three strings, taking care to alternate the ends, as per the diagram. Double check the polarity of each string once you're done. They can be removed while the silicone is still wet, but once it dries, removing them requires destroying the string.

Allow the silicone sealant to fully dry before continuing work on the panel.

There is one more thing you need to do to this solar panel, before you can encapsulate it in its frame, that's to connect the various strings of cells together. If you look at the drawing on the right, you'll see the tabbing wires that you used to make the strings of cells represented by grey lines. There are also purple lines, connecting the various strings of solar cells together. These represent buss wires, used to connect the strings together.

Buss wire similar to tabbign wire, only wider; specifically 5mm wide. It is wider so that it can carry more current. That's not important in this case, but if we were making a large panel, with multiple strings connected together in parallel, we'd need that extra current carrying capacity. The buss wire should have come with your solar cells, just like the tabbing wire did.

As you can see from the diagram, the buss wire is connecting the ends of the strings together, to make one long serial string out of them. Be sure that you make the same connections, so that you will end up with one serial string. If you get one section misconnected, your solar panel will not produce enough voltage.

The buss wire is pre-tinned, just like the tabbing wire is. So, all you have to do to solder the wires together is position them and touch them with a soldering iron. The solder should melt and flow together within two seconds.

The only other thing that needs to be done to the solar panel, in order to make it work electrically, is to solder regular wires to the buss wires at the ends. These wires will end up going through the frame, so that the electrical power the panel produces can go to the rest of the generator. I'd recommend using a red wire for the positive end and a black one for the negative end; 18 gauge wire should be sufficient. Make them about four feet long, as they can be cut later. Electrically speaking, the ends are the two parts at the top of the diagram where the short pieces of buss wire are located. I've put a small yellow lightning bolt at these locations for clarity.

The Solar Panel Frame

Typically, solar panel frames are made of aluminum. While it's possible to use other materials, there are risks associated with them. Wood or steel frames would need to be painted periodically, in order to preserve them and protect them from the weather. Considering that you want your survival generator to last 20 years or more, you're better off with aluminum, because aluminum withstands the weather better.

There are a number of ways of doing the frame for your solar panel, but basically they break down into two groups. You can either buy manufactured frames and install your panel in them or you can make your own. Cost is roughly equal for both, depending on where you get them from. However, if you buy the potting compound and everything else that is available for commercially manufactured frames, it can get quite expensive.

Your purpose here is to encapsulate the solar panel in a weatherproof container, which will allow light to hit the solar cells. So, the front of the panel will be glazed with glass or plastic, and the back will be the plywood you mounted the solar cells to. The frame will hold it all together and seal it.

Glazing

While I am going to talk about using glass throughout these instructions, you aren't limited only to glass for the construction of your solar panels. Glass is the most common glazing material, but it isn't the strongest. Some of the plastic glazing materials are considerably stronger, especially Lexan.

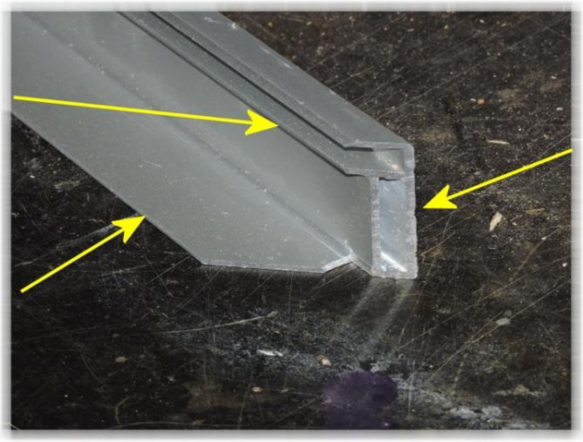
Material	Compared to Glass
Glass	Base material
Tempered Glass	5x stronger
Acrylic	10x stronger
Plexiglass	50x stronger
Lexan	250x stronger

The one thing that's a risk for your solar panels is hail. Of course, you can eliminate that risk by bringing your survival generator indoors in the case of a hailstorm. But in cases where people mount solar panels to the roof of their home, this is an important consideration.

Commercial Frames

Commercial frames are slightly deeper than homemade ones, separating the area for the backing panel from the glass. That actually makes it easier to assemble the frame and helps to ensure that you don't damage the solar cells in the process.

The frame extrusion has a small slot and a larger flange. The small slot provides a convenient place to install the glass and seal it into place. The flange becomes the place for attaching the panel. The individual sides are held together with corner brackets, which are supposed to be staked in place. But I've never been able to stake them successfully. However, that hasn't hurt the quality of my frames.



Manufacturers of these frames recommend assembling three sides of the frame together, staking the corner brackets and then slipping the glass in. I find that I get a better weather seal around the glass if I actually assemble the frame directly to the glass. To do this, it is necessary to set the glass on something, so that all the edges are free. A paint can works well for this. You might want to use a little masking tape to hold the glass in place, but don't overdo it and make it hard to separate them when you're done. In addition to the glass and frame, you'll need clear silicone caulking and some epoxy.

To install the frame to the glass, start by preparing the corner brackets. You'll see that they have a slot in the frame piece where they fit in. Glue the brackets into the short frame pieces with epoxy. This is important, if you glue them into the long pieces, it's harder to assemble. It does not need to set before continuing.

I find it easiest to start by installing one of the long sides. Place a bead of clear silicone caulking in the slot for the glass and then press the frame onto one of the long sides of the glass, centering it carefully. Then repeat for the shorter sides, with the exception of putting epoxy on the corner brackets before installing the frame piece. You will need to slip the angle bracket into its slot first and then the frame onto the glass.

Tape the corners together with masking tape, once the three sides are set in place, as a precaution to hold them in place while setting. With three sides installed, allow the epoxy and silicone to cure before continuing.

The panel with the solar cells mounted on it needs to be installed next. Before installing it, drill a hole in an appropriate place for the wires to pass through. This hole should be big enough that the wires can pass through, without problem, but no more. You're going to have to seal the hole, so you don't want it too big. Be sure to debur the hole after drilling it, so that the sharp edge doesn't damage the wires.

Prop up the frame, with the glass installed, so that it is supported only by the frame flange. The glass should be on the side pointing up. I did this by taping wood blocks to the three installed sides of the frame.

Place a 1/4 inch bead of silicone on the back side of the solar panel backing board, about 1/4 inch from the edge. Run the wires through the hole you drilled in the frame, from the inside out and then slide the panel into the frame, holding it up high enough so that the silicone doesn't make contact with the frame flange. Once it is in position, carefully lower it down to touch the frame, allowing the weight of the board to squish and spread the silicone.

You can immediately attach the fourth side, first putting a bead of silicone in the glass slot and epoxy on the corner brackets. Ensure that it seats properly and tape the corners until it cures. Apply silicone sealant around the wires coming through the hole to ensure that you have a weather-tight seal.

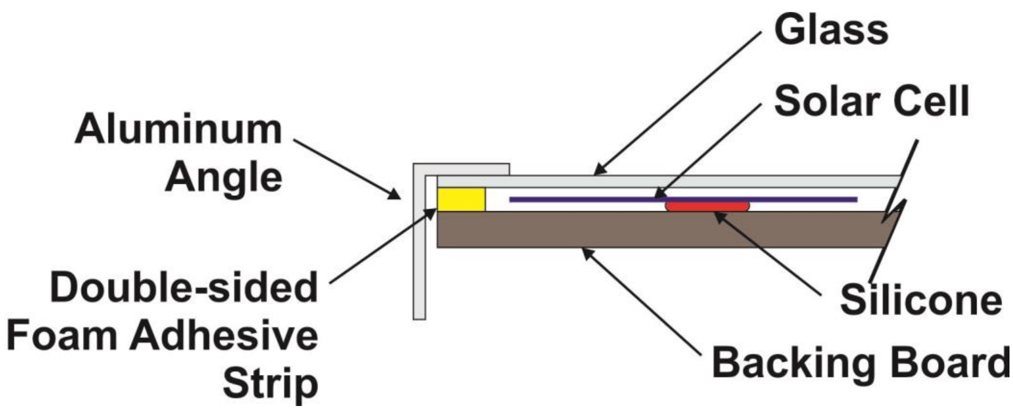
Once cured, the tape can be removed. Run secondary beads of silicone around the glass and the back of the frame, as well as in the corners to ensure that the entire solar panel is moisture-proof. Allow to dry.

Homemade Frames

You can make your own frames out of simple aluminum extrusions that you can buy from a metal supplier. Two basic styles work, the squared C channel or an angle. While many people use the squared C, I find the angle much easier to work with. To me, either is easier than using the commercial frames.

The process is basically the same for both, so we'll cover them together. Basically, you're going to create a sandwich of the backing panel with the solar cells installed and the glass and then install the aluminum frame onto it. The frame helps to hold it all together and ensure that it remains sealed. It also protects the glass from breaking.

To make the sandwich you'll need some double-sided foam adhesive stripping. People often use this for hanging things on the wall, when they don't want to put in a nail. It works well for this application as well. I'd recommend buying it as a roll, as it will be easier to work with and provide a more complete moisture-proof seal.



Measure the thickness of your foam adhesive stripping and compare it to the height of the cells off the top of your backing panel. If they are higher than the thickness of the strip, you'll need to use two layers of it, rather than one. So, whenever I talk about using it, use double.

Place a row of sealing strip all the way around the edge of the backing panel, sticking it to the panel, with the exception of where the wires are to leave the panel. At that spot, you'll need to leave a slight gap, but make it as small as possible. You're going to have to seal that point, so that moisture can't get into the panel.

Peel off the backing paper on the top of the adhesive strip and set four or five dowel rods across the solar panel, supported by the strip. Then place the glass on the dowel rods. This allows you to align the glass to the backing board, without any risk of it sticking.

Once you have the glass aligned to the backing board, you can move all of the dowel rods to one side, allowing you to stick the glass to the backing board along the farthest edge from the dowels. Slide the dowels out and stick the glass to the backing board the rest of the way around. Go over it again to ensure that all edges are stuck.

Before putting the frame around the sandwich, I like to put a thin layer of silicone sealant all the way around the edges, smoothing it out with my finger and making sure that there are no gaps. That ensures that the sandwich is moisture sealed, even though I'm going to seal it again when I put the frame on.

Miter cut the aluminum extrusion or C channel. You can do this with a power miter saw, radial arm saw or hand saw and miter box. The aluminum won't hurt a normal saw blade as aluminum is softer than steel; however it might get caught in the blade's teeth. Make sure that your measurements and cuts are accurate, so that you don't end up with gaps in your frame. You'll also need to drill a hole in ones side, for the wires to go out through.

The pieces of frame are held to the sandwich with the silicone adhesive. For the angle frame pieces, place a bead of clear silicone around the edge of the glass, about 1/4 inch from the edge and anther on the edge of the sandwich. Then attach the frame. For the C channel, put two beads on the inside of the C, on either arm and slip it over the edge of the glass, being careful not to push too hard. Align the pieces and tape them in place to dry.

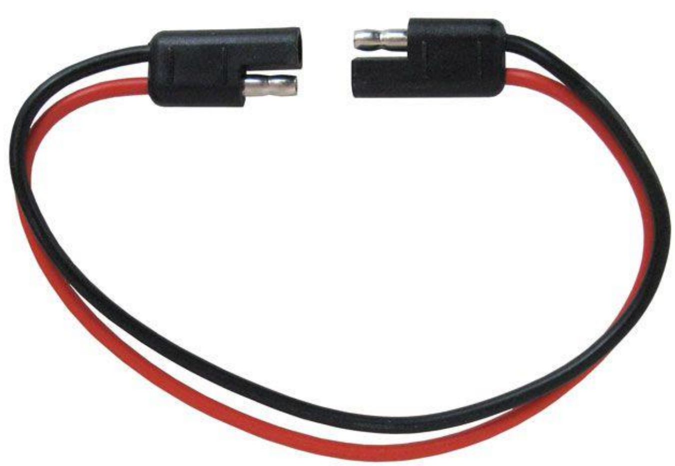
Once dried, the tape can be removed. Add an additional bead of clear silicone caulking on both the front and the back; where the aluminum frame meets the glass on the front and where it meets the wood on the back, to ensure that the unit is sealed.

Connecting the Panels

Your solar panels are going to be used to charge batteries in the battery box part of your survival generator. The more solar panels you have, the more electrical power you can generate, which means that you'll be able to charge your batteries that much faster.

The two wires coming out of the solar panel need to have a connector attached to them, allowing them to be connected to the battery box and then disconnected for storage. I'd recommend using some sort of a weather resistant connector, such as are used for automotive applications, if you can find them. Make sure you solder the connections well and that you make the solder joint waterproof.

The easiest way to make a solder joint waterproof is to cover it with heat-shrinkable tubing. This has to be slipped over the wires before soldering. Once the wires are soldered together, the tubing is slipped over the joint and heated with a heat gun (like a hair dryer, only hotter) or the flame from a butane lighter (carefully) to get it to shrink to half its size. That will usually seal off the solder joint well.



If you are building your generator with multiple solar panels, you'll need to connect them together in parallel. So, you'll have to connect several of these connectors together, on the battery box side, so that the red wires are together and the black wires are together. A single lead (of the same color) can go from there to the battery charger.

Building the Battery Box

Building the solar panels is the hardest part of the project. The rest is considerably simpler. One of our concerns about the rest of the project is protecting it from EMP (electro-magnetic pulse). While EMP won't have much effect on the solar panels (it will degrade them slightly), it destroys solid-state electronics. So, we need to build the battery box in such a way as to protect the electronics from the possible effects of EMP.

This is actually fairly simple to do, by building the box all out of metal or by skinning the box over in metal. A wood box, skinned over in metal, will work for EMP protection, just as well as a metal box will. Electrically speaking, this is called a "Faraday Cage" and it works because metals conduct electricity. So, if an EMP were to hit the box, the box would absorb the EMP, causing it to go around the electronics inside, without touching them. That's the important part.

For the Faraday Cage to work, it's important that the electronics inside not touch the metal skin. I solve this problem by putting in wood shelves and mounting everything to the wood shelves. While not a perfect insulator, wood is fairly good.

What's Going in the Box?

Let's start by talking about what's going to go in the box. We already know that our solar panels are going to be producing a peak of 18 volts DC. That power is going to be used to charge 12 volt, lead-acid batteries, much like car batteries. However, you don't want to use normal car batteries. Normal car batteries are damaged by what's called "deep cycling." That means discharging them more than 50%. Since we're building a survival generator, chances are pretty high that the batteries will be deep cycled many times over.

So, you need to buy batteries that are designed for deep cycling. These are commonly referred to as marine batteries or marine/RV batteries. The basic difference is that the lead plates in the batteries are thicker and there is more space at the bottom of the battery. That way, even though the battery will still be damaged by deep cycling, it will continue to work.

How many batteries you use is up to you and your budget for this project. I have two batteries connected together, in parallel, in my survival generator. That gives me twice the power storage capacity of one battery, meaning that I can run my equipment longer off of it. I also have more than one solar panel, so that I can recharge the batteries quicker.

In addition to the batteries themselves, you'll need a battery charger. This is usually referred to as a "solar charge controller." Although it is charging a 12 volt battery, just like an automotive battery charger, it is different in that it is designed to work off of the 18 volts DC from your solar panels, rather than 120 volts AC wall current.

Solar charge controllers come in a variety of sizes, but you don't need a very big one for what you are doing. The larger ones are for a whole house system, with a battery backup. That's much more than what you're building.

The other thing you need is a voltage inverter. This will take the 12 volts DC stored in the battery and boost it to 120 volts AC to power your household devices. As with the solar charge controller, these come in different sizes. In order to determine the size you need, you'll need to think of how you will use the survival generator. Your voltage inverter must be able to handle the load (current draw) of the most energy hungry device you plug into it.

Let's say that's your refrigerator, just as an example. Perhaps your refrigerator draws 10 amps. But voltage inverters are rated in watts of output, not amps. So, you use the formula I gave you in chapter 2 (A x V = W), to determine that 10 amps is the equivalent of 1200 watts (10 x 120 = 1200). So, you need a voltage inverter that is rated at 1200 watts or more.

Be careful when looking at the ratings on voltage inverters. They actually have two ratings; their continuous power and their peak power. Typically, the peak power is double the continuous power rating. If you run the inverter at the peak power, it will wear out. You need to size it based on its continuous power. That way, when you or your equipment needs an extra boost of power, such as when the compressor on your refrigerator turns on, you'll have the extra capacity available.

One other thing I recommend adding, although it isn't a requirement; that's a couple of automotive cigarette lighter sockets (sometimes called accessory connectors). This will allow you to run 12 volt equipment off of your generator or plug in a USB charger to charge cell phones, tablets and other portable devices.

Hooking it All Together

Connecting the battery box and all its components together is very simple. The hardest part may very well end up being trying to figure out where to run the wires, in order to make it all nice and neat. While neatness isn't a requirement for the generator to work, it does make it easier to work with.

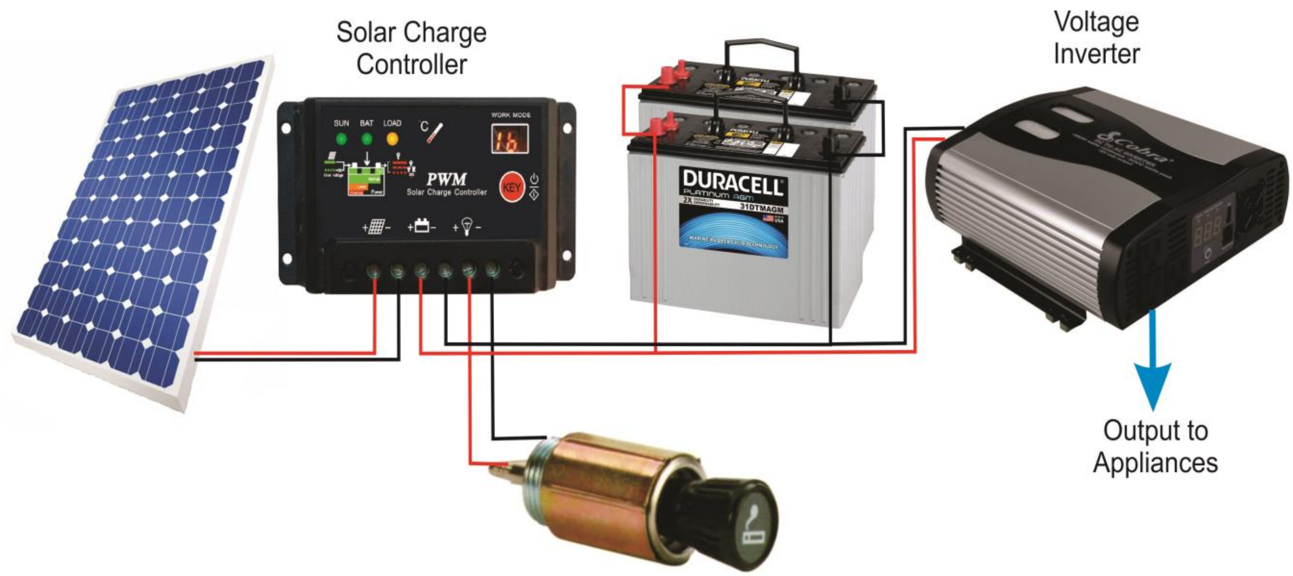
I would highly recommend soldering wires together, whenever you have to make a wire to wire connection. Not only do wires that are just twisted together come apart easily, but they corrode much more easily and once even slightly corroded they provide resistance to the flow of electrons, reducing the efficiency of your generator.

In cases where wires have to attach to screw terminals on the solar charge controller or voltage inverter, I recommend using crimp-on terminals, for basically the same reason that I recommend soldering. While they aren't as good as a solder connection, they are much better than simply wrapping the wire around the screw post and tightening it.

If you look at the diagram below, you'll see all of these items connected together, electrically. The red lines represent positive wires and the black lines represent negative wires. This is standard color coding, and I would recommend using the same color wires to avoid confusion.

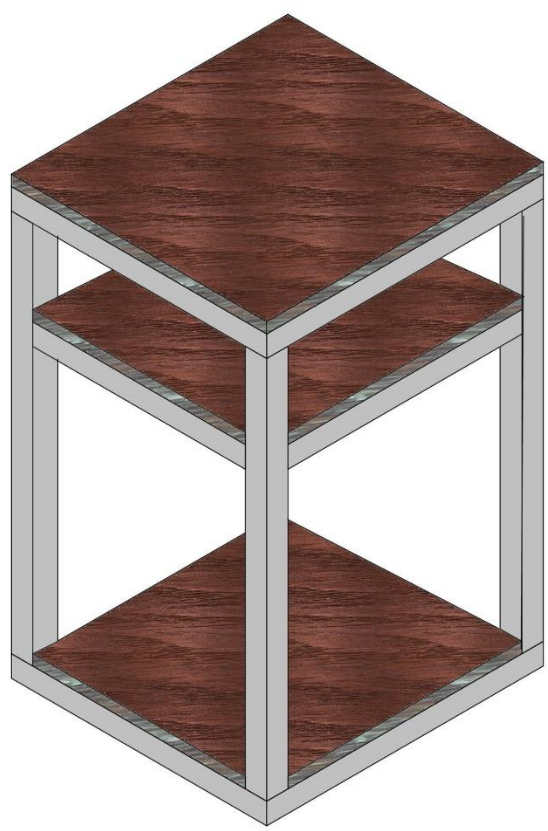
The size wires you use will depend on how much current you actually draw through the system. However, the voltage inverter will probably come with wires to connect it to the battery, so that's not an issue.

Those are the largest wires needed. For the rest of it, I would recommend using 12 to 14 gauge wires. That should be big enough for any current you're going to draw, especially if you terminate them by



soldering or with crimp connectors.

The only case where wires actually come together and might need to be spliced is at the battery. If you look below the battery on the diagram, you'll see that both the red and black wires T. This does not have to be separate of the battery and probably shouldn't. It's easier to make this connection by connecting both sets of wires to the battery terminal.



Building the Battery Box

The battery box itself can be built in a wide variety of ways. Essentially it needs to be big enough to hold all of the electrical components we've talked about, with the exception of the solar panel or panels that you built. It is also a good idea to make the generator portable; so you'll need to put castors on it to move it around with.

I recommend building a two-shelved box, so that the batteries can sit on the bottom shelf (the bottom of the box) and the other electronic components can sit on the top shelf. A simple hole with a grommet in it can allow wires to pass between the two.

In the drawing on the right, we see a basic cabinet for the survival generator. The framework is made out of 1" square steel tubing. Plywood shelves, 1/2 inch thick are attached as the top, middle shelf and bottom shelf. A hinged door will need to be added and the entire thing covered in aluminum or steel sheeting. If you can get aluminum, it will be easier to cut, bend and work with.

This cabinet is about 18 inches square by two feet high. That gives you enough room for two batteries in the lower part, and the electronics on the upper part. If you are going to use more batteries, you will need to make it bigger, either by adding another shelf and making the whole thing taller or by making the cabinet wider to accommodate the additional battery.

The idea, as I mentioned earlier, is that the casing can act as a Faraday Cage. With all the electronics contained within, an EMP would not destroy them. At the same time that the cage is protecting the components electronically, it is also protecting them physically and making the unit easy to use.

You will need to be able to connect the solar panel or solar panels to the battery box. For this, drill a small hole in the side of the box, put a grommet in it and run the wires through it. Ideally, you want this hole as small as possible, so wait until the wires are run through, before putting the connector on the wire. You also want the pigtail for that connector as short as reasonably possible.

One of the things ways that an EMP can get into electronic equipment to damage it is via what is known as the antenna effect. Long wires act as an antenna, just like a telescoping antenna on a radio. This can capture the EMP and channel it into the equipment, even though it is in a Faraday Cage. By using only a short pigtail for the connector, you eliminate this risk, protecting your equipment from any negative effects of an EMP.

Using Your Survival Generator

Using the survival generator is actually a two-stage operation, although both stages can actually be done at the same time. The two stages are:

- Charge the generator
- Power your electronics

Charging the Generator

In order to charge the generator's batteries, the solar panel will need to be set in the sun and connected to the battery box. So, take your solar generator outside and find a good sunny spot in your backyard. Using a compass, point the solar panel south. It's also important to set the panel at the optimum tilt for the latitude of where you live and the season.

You'll need to calculate the angle of the panel, based on the latitude of where you live. We're going to look at three different ways of doing this calculation.

Fixed Tilt

Fixed tilt means that you will be using the same angle the whole year through. This is the least efficient way of producing power from a solar panel. However, it still works. To calculate the angle:

- Multiply your latitude by 0.87 if you live in a latitude below 25 degrees
- Multiply your latitude by 0.76 and then add 3.1 degrees if you live

in a latitude between 25 and 50 degrees (this covers the entire continental United States)

The figure you receive should be the angle towards the south that you tilt the panel. In other words, if you take laying the panel horizontally on the ground as zero degrees, lift the north side of the panel enough so that the angle between the panel and horizontal is at what you calculated.

2 Season Adjustment

If you are going to change the tilt of your panels twice per year, you'll want to adjust to the winter angle on September 21th and to the Summer angle on March 30th. This will give you an additional 5% of efficiency from the solar panels.

- To calculate the Summer angle, multiple your latitude by 0.93 minus 21 degrees
- To calculate the Winter angle, multiply your latitude by 0.875 plus 19.2 degrees

These angles are applied the same way as mentioned above in the Fixed Tilt section.

4 Season Adjustment

Some people adjust the tilt of their panels four times per year, seeking to get more efficiency. However, you only gain another 1/2% of efficiency for doing this. Nevertheless, to do this:

- Adjust to Summer angle on April 18th. This is calculated at 0.92

times the latitude, minus 24.3 degrees

- Adjust to Autumn angle on August 24th. This is calculated at 0.98 times the latitude, minus 2.3 degrees
- Adjust to Winter angle on October 7th. This is calculated at 0.89 times the latitude, plus 24 degrees.
- Adjust to Spring angle on March 5th. This is calculated at 0.98 times the altitude, minus 2.3 degrees, just like the Autumn angle is calculated

The only way you can gain better efficiency than this is to install your solar panels on a 2-axis tracker. While this does provide another 25% efficiency, which is more than the tracker's power consumption, the cost of the tracker is fairly high. For this reason, few people bother with a tracker.

Powering Your Electronics

In order to power your electronics from the survival generator, you need do no more than to move the generator near the devices you want to power and connect them to the AC outlets which are included in the voltage inverter. You can also connect devices to the 12 volt connections you installed or connect to the 12 volt connections via USB charging cable.

It is important to remember that this is only an emergency power source, not a full power source for your home. The amount of power you will have available to you will be limited by the battery capacity. This is marked on the battery as "Reserve Capacity." This figure refers to the amount of time that a battery can maintain a 25 amp discharge and still retain enough power to be useful. For our purposes, that means that the voltage hasn't dropped to the point where the battery can't power anything.

But, and again I say but, when the voltage inverter boosts the 12 volt DC power in the battery to 120 volt AC power, it has to come up with something to use to make that jump. The way it does this is described by the formula:

$$V_1 \text{ x } A = V_2$$

In this formula, V_1 is the voltage in the battery; V_2 is the voltage we want to end up with. A little simple algebraic manipulation of this formula shows us that A has to equal 10. So, in order for the voltage inverter to boost the voltage of power, it has to use ten times as much amperage. In other words, if you are connecting a device that draws 10 amps of power to operate, the voltage inverter is going to have to draw 100 amps of power from the battery.

This may very well mean that your batteries go dead much faster than you like. So, you want to closely monitor your power usage and be sure to only use your emergency generator for the most important electrical equipment you have. If you allow your children to use the power in your batteries to play video games, you may not have any power for more important uses.

Another part of this is to make sure you are only using energy efficient equipment with your generator. Light bulbs, which may not seem to draw much power, actually draw quite a bit. CFL bulbs draw much less. But if you want the most energy efficient light bulbs, then use LEDs.

Anything that has a motor or a heating element in it is also going to use a lot of power. That means pretty much any home appliance you own, as well as your refrigerator. While a refrigerator may not seem to have a motor in it, the compressor contains a motor. Hot water heaters, electric stoves and toasters all have heating elements. Microwave ovens are actually more energy efficient.

If you can 12 volt power for something, that will be more efficient than using 120 volt power for it. There is a little bit of efficiency loss in the voltage inverter, as well as in any power supply that a device uses. So, by pulling the power needed directly from the 12 volt battery, through your cigarette lighter connectors, you save energy that you can use for other things.

Prioritize your electrical needs and use your emergency generator for those things. There are many things, such as cooking, which can be done without using electrical power. We're just used to using electricity for it. But in a survival situation, you'll need to do better.